FLOW ANALYSIS OF AIR DUCT SYSTEMS

BY

STANLEY FRANCIS GILMAN

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FLOW ANALYSIS OF AIR DUCT SYSTEMS

The various elements making up air duct systems are classified into through-flow and divided-flow types, and a critical evaluation is made of the nature of the pressure losses and methods of evaluating them. Theoretical concepts are applied to representative through-flow elements and comparisons made with available experimental data. It is shown that one additional variable; namely a flow-rate ratio, is involved in divided-flow elements and that, on the basis of theoretical principles, the behavior of the loss curves can be explained in a rational and conclusive manner.

Presently accepted methods of duct design are examined and their merits and limitations presented. The equivalent length and equivalent diameters concepts are analyzed and their restrictions discussed. The use of a static-pressure concept as a criterion of duct design is criticized and its replacement with a stagnation-pressure (total-pressure) concept is recommended, since the latter, under conditions of constant air density, is consistent with basic physical principles and, as a consequence, produces consistent results.

A method of duct design utilizing a stagnation-pressure concept and based on fundamental principles of fluid mechanics is proposed. The method lends itself to a simple, accurate procedure which results in the dissipation of the minimum amount of mechanical energy for a balanced system. Consequently, for a given available stagnation pressure, it is possible to determine all duct sizes; also, for a given duct system, the required stagnation pressure can be evaluated.

Duct designs are classified into those for which unique solutions are obtained directly and those for which trial solutions are required. Example problems are presented and a trial-and-error procedure is demonstrated. A graphical method of obtaining unique solutions for special problems involving divided-flow elements of a particular geometry is developed and illustrated.

It is shown that trial-and-error procedures can generally be replaced by a rapidly converging iteration method which minimizes requirements as to reasonable assumptions. The iteration method developed is also applied to practical problems for illustrative purposes.

VITA

Stanley Francis Gilman was born on March 31, 1921, in Portland, Maine. After graduating from Deering High School in Portland, he entered the University of Maine in 1939 and received the degree of Bachelor of Science in Mechanical Engineering in May 1943.

From May 1943 until February 1946 he served as a Naval Officer and was assigned to Bureau of Ordnance duties in the continental United States and in the Asiatic-Pacific Theatre. Upon separation from the Navy, he became Co-Partner of a heating and ventilating company in Portland.

He entered the Graduate College of the University of Illinois in February 1947 and received the degree of Master of Science in Mechanical Engineering in June 1948. He held a Graduate Assistantship from February 1947 to September 1947, at which time he began full-time research duties in the Department.

From September 1947 to the present, he has been engaged in research dealing with air duct systems and air distribution in rooms as related to the field of heating, ventilating, and air conditioning. He is author or co-author of ten publications having to do with his research.

He is member of Tau Beta Pi, Pi Tau Sigma, and Sigma Xi; and is also presently a member of the Technical Advisory Committee on Air Distribution of the American Society of Heating and Ventilating Engineers.